

The Ecology of the *Ides Idus* (L.) in the River Kävlingeån, South Sweden

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The dissertation is based on the following publications:

- I. Cala, P. 1970. On the ecology of the Ide *Idus idus* (L.) in the River Kävlingeån, South Sweden. Rep. Inst. Freshw. Res. Drottningholm No. 50: 45-99.
- II. Cala, P. 1971. Effects of alcohol on length and weight of young-of-the-year Ide *Idus idus* (L.) and Roach *Rutilus rutilus* (L.). *Caldasia* XI: 193-201.
- III. Cala, P. 1971. Scale formation as related to length of young-of-the-year Ide *Idus idus* and Roach *Rutilus rutilus*. J. Zool., Lond., 165: 337-341.
- IV. Cala, P. 1971. Size and age at maturity, ripening and fecundity of the Ide *Idus idus* (L.). Rep. Inst. Freshw. Res. Drottningholm No. 51: 31-46.
- V. Cala, P. 1970. The development of the oocytes and seasonal changes in the ovary of the Ide *Idus idus* (L.) in the River Kävlingeån, South Sweden. *Caldasia* X: 579-594.
- VI. Cala, P. 1975. Age at maturity, testicular development and seasonal changes in the testes of the Ide *Idus idus* (L.) (Pisces: Cyprinidae). pp 16 & 12 Figs. Manuscript.



S Y N O P S I S

Various aspects on the biology of the teleost fish Idus idus (L.) (Family: Cyprinidae) have been previously studied. However, there is little information, apart from short studies on early development, spawning and diet, on the ecology of the fish in Sweden.

The present dissertation is concerned with the life history of I. Idus in the River Kävlingeån in southern Sweden, with regard to age, growth, body scale relationship, length and weight relationship, food habits, spawning, age and size at onset of maturity and the development and annual cycle of the gonads.

G E N E R A L S U M M A R Y

I. Spawning, growth and age, sex ratio on spawning ground and food habits.

This study is based on data from the Idus idus (L.) collected in the lower part of the River Kävlingeån - Högsmölla to the mouth. The studies were carried out during a 4-years period (1963 - 67).

A list of the literature about the ide's biology in different countries, with special reference to Scandinavia, has been produced.

A physico-chemical analysis (water temperature, colour, pH, hardness: Ca + Mg, specific conductivity, chloride ion contents and oxygen contents) of the study area was realized. Large changes, from time to time, of some of these physical properties of the river water was noted.

Death of fish in the River Kävlingeån have been noted since 1910 (Swenander) as a result of low oxygen content, combined

with high temperature and pollution caused by discharging of water coming from Örtöfta sugar factory and other industries and urban districts.

Qualitative notes on the biomass (benthic fauna, plankton, fish and fishery) of the lower part of the River Kävlingeån has been described.

The larger movement of the ide occurs in the lower reaches of Kävlingeån. The ide spends the first year of its life in the river and then joins with other migrating fish to the sea. During summer (June - August) ide older than age group 0 disappear almost completely from the river, spending the summer in the sea. In autumn the ide return to the river, the smallest ones in September and as the autumn advances the schools increase in number and size. Generally, the largest ide leave the river earlier (April to May) and return later (October to November).

The spawning of the ide in the River Kävlingeån during the 4-year (1964 - 67) study period occurred from 29 March to 17 April. The ide spawn in shallow streams at depth of 0.5 - 1.5 m. The eggs adhere to stones, plants, etc. The largest fish spawn first. Spawning began 2 to 3 days after the daily water temperature reached and remained about 5 °C. Most ide spawned during 2 to 3 days when the water temperature rose to about 7 °C and the weather was fine. But if the water temperature drops after the initial period of spawning, additional spawning takes place when the temperature rises again.

Eggs from ide, in the laboratory, began to hatch after 5.5 days at a mean temperature of 13.8 °C and after 23 days at a mean temperature of 9.3 °C. Thus, low temperature retards hatching, and below 5 °C there is no hatching. The length of the fry-sac at hatching ranged between 5.8 - 6.6 mm.

It has been realized a growth analysis of 1081 young-of-the-year and 433 ide specimens older than age group 0 of the lower reaches of the River Kävlingeån. It was concluded from the results of the years 1965 and 1966 that the growth season of the young-of-the-year ended in early November. The fry have then attained a mean total length between 6.8 and 7.6 cm for the respective years. The size class means indicate the body-scale relation, of ide older than age group 0, to be described by three straight lines. The straight line fitted by least squares to the means of fish lengths and scales radii had these equations:

$$\begin{aligned} L &= 35.92 + 2.1014S & (L < 15.3 \text{ cm}), \\ L &= 80.77 + 1.4720S & (15.3 < L < 40.3 \text{ cm}), \\ \text{and } L &= -106.37 + 2.3236S & (L > 40.3 \text{ cm}), \end{aligned}$$

where L equals total length of fish in mm and S equals length of anterior scales radius (X30) in mm. The body length at the end of any year of the life for a specimen was calculated from the respective figure (relation between total length and scale radius). The calculated average lengths for males (101 specimens) and females (132 specimens) showed no significant differences. Males and females ide show their greatest annual increase in length during the second year of life.

Annulus formation usually occurs around early May and is completed about the end of June. It seems that older ide, especially mature fish, form annuli earlier than the younger ones. The regulation of scales was affected by the water temperature.

Length-weight relation is based on data from 989 young-of-the-year ide, and from 428 yearling and older fish. The length-weight relationship in relation to sex, sexual maturity or state of gonads revealed no differences. The length-weight relationship of the ide was linear when both variables were trans-

formed to common logarithms^m, except fry below 13 mm in average length. The general parabola $W = cL^n$, where W = weight, L = total length, and c and n are empirically estimated constants has been used to describe the length-weight relation. Thus, the length-weight equation, determined by fitting a straight line to the logarithms of the lengths and weights, are:

$$\begin{aligned}\log W &= -5.11749 + 3.03175 \log L \quad (\text{young-of-the-year}), \\ \text{and } \log W &= -5.77664 + 3.33853 \log L \quad (\text{yearling and older ide}),\end{aligned}$$

where W = body weight in g and L = total length in mm. The value of n indicates that the body weight increases approximately as the cube of the length for young-of-the-year longer than 12 mm in length and more rapidly than the cube of the length for yearling and older ide. The equation makes possible the calculation of the unknown weight for a known length and vice versa. It becomes evident that the total length of an ide at a weight of 1 g is 52 mm and at a weight of 1 kg 453 mm. The greatest annual increment in weight of 239 g occurred in the 10th year of life, despite the fact that the greatest annual increments of length were attained during the 2nd year.

A sample of 1207 adult ide taken just before and during the spawning season in 1964 between 1 April and 2 May was composed of 621 (51.4 %) mature males and 586 (48.6 %) mature females. These numbers do not deviate significantly from a 1 : 1 ratio ($\chi^2 = 0.30$).

1163 ide from the lower reaches of the River Kävlingeån were examined with regard to the stomachs' contents. In the present material there were definite changes in food habits with increase in size which became evident at about 20 mm length, and at about 140 mm. Crustacea were most important in the first group (10 to 20 mm total length), but insects predominated in the second group (20 to 140 mm), especially chironomid

larvae. Rotifers were taken by a considerable number of fish, but only by fry below 12 mm. Cladocera were caught by fish between 10 and 80 mm and Copepoda until 60 mm. In age groups just larger than 140 mm several food items became important such as higher plants, Asellus aquaticus, and Oligochaeta. Insecta continued to be an important group, Chironomidae become less dominant as the fish grow and at above 260 mm they are replaced by higher plant tissue. This study shows that the ide in its early life does not specialize on either Copepoda or Cladocera, but there seems to be a tendency for fry to feed more heavily on Cladocera when these organisms are abundant. There seemed to be no definite preference in the food choice by ide. There are small seasonal variations of the feeding habits of the ide. Plant material is eaten mainly in summer and early autumn, when the vegetation is luxuriant. It should be noted that large ide spend most of the summer in the sea where their diet consists of marine matter.

II. Effects of alcohol on length and weight of young-of-the-year fish.

Changes in length were recorded by sequential measurements of fish killed and stored in 80 % ethanol. Young-of-the-year ide shrank to 96 % (fish below 20 mm or without any scale) and to 98 % (fish larger than 20 mm or with scales) of original total length in less than 24 hours, and subsequently the smaller fry, shrank to about 95 % while the larger ones showed no further change.

Young-of-the-year roach shrank to 94 % (fish below 20 mm) and to 98 % (fish larger than 20 mm) of original total length in less than 24 hours. Subsequently, the smaller fry shrank to about 93 %, while the larger ones showed no further significant change.

The proportionate changes in weight among fishes of different

sizes varied very little. Young-of-the-year ide and roach diminished to about 80 % of their original weight in less than 2 days. Further changes with time were considered insignificant, except in fish below 20 mm. The apparent different loss of weight in ide and in roach (below 20 mm) could be due to some systematic error during measurements, because the age and length of the fish of the samples were more or less the same.

Changes in length and weight were recorded during anaesthesia and after the death of fishes kept in water and without it. It was concluded that, for fish under anaesthesia, weight must be observed as soon as voluntary movement ceases in order to approximate the live weight. Prolonged anaesthesia (although respiratory movement may continue) and death affect osmoregulation. Fish kept in freshwater after death gain weight and shrink less in comparison with fish kept out of water, which lose weight.

In accordance with Parker (1963) it can be concluded that no standard correction terms would be generally usable. Correction terms would have to be determined for each study taking into account the original state and size of fish, type and ionic concentration of the preservative and the length of time during which the fish is stored in it. Thus, the correction factor can be different, for instance, even for the same species, for those who consider the factor rigor mortis and for those who do not.

III. Scale formation as related to length of young-of-the-year fish.

The smallest ide with at least one scale measured 21 mm total length. The first scale appeared under the middle line on the caudal peduncle and the scale pattern spreads from that point anteriorly, a second row began to appear around the first. The increase of number of scales in both rows was proportio-

nal, so that the first line was always longer and possessed larger scale nuclei. The first fish that was completely scaled was 34 mm long, and also all other fishes larger than 35 mm.

The largest roach without any scale measured 20 mm total length, and the smallest with at least one scale, 17 mm. The first scale appeared along the lateral line on the caudal peduncle and the scale pattern spread from that point anteriorly along the lateral line, similarly to that of the ide. The first fish that was completely scaled was 30 mm long, and also all other fishes longer than 31 mm.

IV. Size and age at maturity, ripening and fecundity of the ide.

An examination was made of ide from the lower part of the River Kävlingeån from November 1964 to spring 1967. Fish with well developed gonads apparently capable of producing mature gametes during the current year were considered to be mature.

All ide shorter than 31.5 cm in total length were immature, and all longer than 43.1 cm were mature. The shortest mature male was 39.2 cm long. All males were mature at lengths greater than 40.1 cm. The shortest mature female measured 31.5 cm. All females longer than 43.1 cm were mature. Males reached 100 % maturity at a length 3 cm less than the females. Further, this study showed that ide younger than age group VI were immature and all older than the VII age group were mature.

Ripening females (2 weeks before the spawning) contained eggs in three stages of development: 1a) unripe: 100 - 250 μ m diameter, clear, nucleated egg cells; 1b) unripe: 300 - 500 μ m diameter, oil globule vaguely discernible, especially in the largest ova, egg with clouded appearance; 2) ripening: 0.5 - 1.3 mm diameter; and 3) ripe: 1.30 - 1.85 mm diameter, mean 1.50. The eggs ready to be laid and fertilized have a mean diameter

of about 1.70 mm. 24 hours after the eggs have been deposited they have a mean diameter of about 2.3 mm.

Females that would be ripe in April (spawning time) can be distinguished from immature females as early as in the previous July on the basis of examining the mean diameter of 30 of the largest ova. The largest increase in diameter of the ova occurs in August when the eggs have reached a mean diameter of about 1.3 mm in the middle of the month. In November the ova have the size that they have just prior to spawning or when the eggs become ripe.

The higher the ripening index, the higher the degree of ripeness. There is some evidence that the males ripen earlier in the season than the females do. It further seems that older (or larger) fish ripen earlier in the season than do those which are smaller or spawn by the first time. This is in accordance with the first appearance of the males on spawning grounds and also with the fact that the largest ide spawn first (Cala 1970₂).

The total numbers of ripe eggs ranged between 42,279 - 263,412, approximate mean 122,000. A scatter diagram of the number of eggs plotted against the total length of the fish gives a relation expressed by the formula:

$$\log F = - 3.63017 + 3.4358 \log L$$

The relation of body weight can be described by a straight line, with the mean number of eggs increasing from approximately 30,000 for a 500 g female to about 193,000 for a 2,000 g female, i. e. the fecundity increased by about 53,000 eggs for each increase of body weight of 0.5 kg within the range 0.5-2 kg. This relation is expressed by the formula:

$$F = - 25.4262 + 0.1094 W$$

A similar relation was made of the number of ripe ova to the

age and to the total weight of the ovary of the fish. The linear relations were expressed by the formulas:

$$F = -99.6154 + 25.2074 A$$

$$\text{and } F = 44.5508 + 0.2721 X$$

Where, F= number of eggs, L= total length, W= body weight,
A= age of the fish and X= weight of the ovary.

V. The development of the oocytes and seasonal changes in the ovary of the ide.

In this study the oogenesis of the ide has been divided into five stage in the immature fish and three in the mature specimens.

IMMATURE IDE

Stage 1. Gonad invisible. In fry up to 50 mm in total length.

Stage 2. Sexually undifferentiated gonad. The gonad consists of a pair of strings located in the body cavity ventral to the kidneys, lateral to the swim bladder and with different types of cells. At this stage the internal structure of the gonad is diffuse.

Stage 3. Formation of oogonia and early oocytes. The oogonia are medium-sized mean 11.8 μ m, spherical cells with large round nuclei, mean 8.6 μ m and without visible nucleolus. Oocytes were on average 32.4 μ m in diameter and the nucleus had a mean size of 21.9 μ m. The nucleolus is difficult to observe. A dense body appears in the cytoplasm which later disappears with the growth of the oocyte.

Stage 4. Basophilic oocytes with large nucleoli occur. In the beginning the oocytes are on average 90 μ m in diameter with a

nucleus on average $47.3 \mu\text{m}$. One or several nucleoli are found at the periphery of the nuclear membrane. At the end of the stage when the oocytes have reached a diameter of on average $207.4 \mu\text{m}$ and the nuclei $107.6 \mu\text{m}$, the nucleoli have increased in number and diminished in size.

Stage 5. The beginning of vitellogenesis. Yolk first appears in oocytes of on average $250.2 \mu\text{m}$ in diameter, whose nuclei measure on average $102.8 \mu\text{m}$. The primary yolk globules appear in a ring within the cytoplasm rather near to the cell membrane. At the beginning of vitellogenesis, fine granules begin to accumulate immediately beneath the membrane, forming a very dense granular cortical layer. The cortical layer gradually becomes thicker, and a radial striation becomes visible in it. Successive layers of yolk globules form centrally from the primary layer.

MATURE IDE

Stage 6. Maturing oocyte. The nuclear membrane desintegrates and the nucleoli disappear. The cytoplasm is more or less filled with yolk globules. Early in this stage (in July) the oocytes have a mean diameter of 0.85 mm in fresh conditions, then the oocytes mature very rapidly. This maturation is characterized by extensive yolk deposition accompanied by considerable increase in size. A rapid thickening of the zona radiata occurs, measuring $6 \mu\text{m}$ in July. Thus, females with oocytes in stage 6 are mature, i. e. they will oviposit in the next spawning season.

Stage 7. Mature oocytes present. The oocytes are almost as large as ripe eggs, i. e. 1.48 mm in diameter, but whereas the yolk is eosinophilic numerous vacuoles appear in the yolk-filled cytoplasm just beneath the zona radiata, which now measures $18 \mu\text{m}$ in thickness with typical radial strations. Outside the zona radiata there appears a special " apparatus for fastening

the eggs " (Raven 1961), consisting of long threads. This layer grows around the maturing oocyte and remains to the end of the oogenesis.

Stage 8. The ripe egg. Living ripe eggs are relatively strongly adhesive. They are spherical, about 1.7 mm in diameter, transparent, and are covered with a thick egg membrane.

The first sign of an undifferentiated gonad appeared, in ide from River Kävlingeån, after the first growth season or in fish about six months old. The first oocytes appear during the second summer of the fish life. Oocytes in stage 5 appear, as a rule, in ovaries of fish age group IV, but some times they occur in age group III. This stage in one year develops into stage 6, when the fish is mature and the oocytes start to mature. Thus, the females ide may become mature at an age of four years, usually however, at five years age. It means that the female ide can spawn for the first time in the 5th year of life, but mostly in the 6th.

VI. Age at maturity, testicular development and seasonal changes in the testes of the ide.

This study establishes at which age the male ide in a population inhabiting the River Kävlingeån, South Sweden, reaches maturity and describes the development of their spermatogenic cycle in relation to the environment. The spermatogenic process of the ide has been divided into three stages in the immature fish and four in the mature specimens, on the basis of the morphohistological changes in the testes. Stage 1.- Gonad invisible. Stage 2.- Sexually undifferentiated gonad. Stage 3.- Formation of spermatogonia. Stage 4.- Beginning of maturing or formation of the first spermatocytes. Stage 5.- Formation of spermatids and spermatozoa. Stage 6.- Completely mature viable spermatozoa. Stage 7.- Period of involution. The first

sign of a sexually undifferentiated gonad appeared in ide about six months old or class 0+ (Cala 1970b). The first spermatogonia appear during the second growth season. Spermatocytes (stage 4), when the fish becomes mature, as a rule, appear in testes of ide belonging to age group IV. Thus, in nine months the ide develop into stage 6, when the fish is mature and the spermatogonia start to mature. That is, the male ide become mature at an age of four years and spawn for the first time at five years age. This agrees with the age at maturation of oogonia (Cala op. cit.).

A C K N O W L E D G E M E N T S

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